

The development of a fish index to assess the biological integrity of South African rivers

CJ Kleynhans

Institute for Water Quality Studies, Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001, South Africa

Abstract

A biological integrity index that uses attributes of fish assemblages was developed and applied to a part of the Crocodile River (Incomati System, Mpumalanga Province). Fundamentally, the fish assemblage integrity index (FAII) is based on the fish species expected to be present in biological (fish habitat) segments which are sections of river with relatively homogeneous fish habitat. Within this framework fish are categorised according to an intolerance index which takes into account trophic preferences and specialisation, habitat preferences and specialisation, requirement for flowing water during different life-stages and association with habitats with unmodified water quality. This intolerance index, the expected frequency of occurrence and expected health of fish species in a particular fish habitat segment was used to formulate an index for the situation expected under minimally impaired conditions which was used as the comparative basis for the observed (sampled) situation. The observed situation was expressed as a fraction of the expected situation to arrive at a relative FAII index value which was grouped into one of six descriptive fish assemblage integrity index classes. It was found that the index reflected several aspects of the modifications that have occurred in the Crocodile River, i.e. water quality modifications, flow modifications and introduction of alien fish. However, flow releases from Kwena Dam hampered fish sampling while the floods that occurred in the summer prior to the survey, extensively modified physical habitat conditions that existed for some years. It was concluded that the index provides a broad, synoptic estimation of the biological integrity of the river. It is highly likely that the index in its current form provides an underestimation of the biological integrity due to the species expected to be present, being based on all species listed for a segment, and not on the fish species expected to be present in the habitats actually sampled. It is suggested that refinement of the index should include development of improved methodology to determine not only the fish species expected per segment, but also species expected per habitat type. In its current form, the index has the potential to provide qualitative, descriptive criteria for the desired ecological condition or integrity of rivers for management purposes in terms of the new South African Water Law. The development of numerical criteria will, however, require development in terms of the statistical properties (i.e. statistical power) of the index.

Introduction

The South African Department of Water Affairs and Forestry (DWAF), as custodians of the water resources of the country, initiated the development of a National Aquatic Ecosystem Biomonitoring Programme during 1995 (Roux, 1997). The purpose of this programme is the determination of the integrity or health of aquatic systems using biota. However, it must be pointed out that a distinction can be made between biotic integrity which represents comparison with near-natural conditions, and health which represents conditions desired by humans but not necessarily natural (Karr, 1996). The emphasis of this paper is on biotic integrity which has been defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a full range of elements (genes, species and assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of the region" (Karr, 1996).

Macro-invertebrates have for some time been used as indicators of the biological integrity of flowing waters in South Africa. The most recent in this respect is the SASS community index (South African Scoring System; Chutter, 1998). Fish received general attention with reference to the intolerance of certain species to particular environmental conditions in South Africa (i.e. Kleynhans et al., 1992) but attributes of fish communities were

never integrated into an index context.

In the Okavango River of the neighbouring Namibia, attempts were initiated (Hocutt et al., 1993) to select metrics for the development of an index that approximates the North American Index of Biotic Integrity. Hay et al. (1996) carried this attempt further but included water quality characteristics in their index. This deviates from the typical approach, which only considers biological components in terms of their reaction towards perturbations but does not take into account the perturbations themselves.

The purpose of the South African initiative is to develop an index that can use readily available and measurable fish assemblage attributes that are responsive to human-induced environmental changes. The first effort in the development of a fish integrity index will concentrate on rivers. Following this, natural lakes, wetlands, estuaries and impoundments will receive attention. In this context the following objectives of the envisaged fish index were specified:

- The index must, in conjunction with other indices of biotic integrity, provide information to inform the South African public of the state of the nation's rivers on a regular basis.
- It must be usable within the limits of the available information, labour, expertise and financial resources.
- It must be structured in a fashion that allows easy adaptation (i.e. recalculation of historic index values) when information on fish assemblages improves.
- It should provide information and answers within the context and framework of the recent (1998) legislation on South African water resources. This legislation makes provision for

* To whom all correspondence should be addressed

☎ (012) 808-0374; fax (012) 808-0338; e-mail eeo@dwaf-hri.pwv.gov.za
Received 1 December 1998; accepted in revised form 30 April 1999.